# Export Expansion, Skill Acquisition and Industry Specialization: Evidence from China

Bingjing Li

National University of Singapore

2nd Annual Bank of Canada-University of Toronto-Rotman Conference on the Chinese Economy

Oct, 2016

# Introduction

- Impacts of import competition from China:
  - Pierce and Schott (2012); Ebenstein, et al. (2012); Autor, Dorn and Hanson (2013); Autor, et al. (2014), etc.
  - Flip side of the coin? Han, Liu and Zhang (2012); Cheng and Potlogea (2015)
- This paper
  - Impacts of export demand shocks on human capital accumulation or decumulation in China over the period 1990 to 2005
  - Evolution of industry specialization resulting from the export induced shift in skill supply
  - Spatial variation in export exposure in China, stemming from the initial regional differences in industry composition

# Introduction

## Literature

- Dynamic Heckscher-Ohlin Model: Stiglitz (1970), Findlay and Kierzkowski (1983), Borsook (1987)
- Trade encourages skill acquisition: Burstein and Vogel (2012) and Danziger (2014)
  - Emphasizing within-sector reallocation induced by trade
  - Counter micro evidence in China: Ma et al. (2014)
- Empirical work
  - Income effects: Edmonds and Pavcnik (2005) and Edmonds, Pavcnik and Topalova (2010)
  - Greenland and Lopresti (2016): China's import competition raises the high school graduation rates in the US
  - Skill intensities matter: cross-country evidence, Blanchard and Olney (2014); Mexico evidence, Atkin (2016)

# Introduction
## Literature (Continued)

- Building on these earlier contributions
  - Develop a theoretically consistent approach
  - Draw on a sub-national data set
  - Exploit the vast geographic diversity of China
  - Study the feedback effect of endogenous change of skill supply
- Impact of trade on local economy: Topalova (2010), Edmonds, Pavcnik and Topalova (2010), McCaig (2011), Autor, Dorn and Hanson (2013), Kovak (2013), Dix-Carneiro and Kovak (2015), Costa, Garred and Pessoa (2016), etc.

# Introduction
## Main findings

- Export expansions have differential effects on human capital accumulation, depending on a region's initial industry composition
  - Over the period 1990 to 2005
    A std $\uparrow$ in $\Delta Export^L \implies \downarrow$ high school by 3.0 % and college by 2.7 %
    A std $\uparrow$ in $\Delta Export^H \implies \uparrow$ high school by 0.9 % and college by 1.3 %
- Endogenous skill formation reinforces the regional industry specialization
  - A 10 % $\uparrow$ college enrollment in the 1990s $\implies$ $\uparrow$ a high-skill industry by 0.87 %; $\downarrow$ a low-skill industry by 0.78 % in the 2000s
- Implications on long-term effects of trade and regional inequality

# Roadmap

- A Trade Model with Endogenous Labor Supply
- Regional Export Demand Shocks
- Data Sources
- Export Expansion and School Enrollment
- Feedback: Skill Supply and Industry Specialization

# A Model with Endogenous Skill Supply

## Building Blocks

1. A Roy model of educational choice
   - Lagakos and Waugh (2013), Hsieh et al. (2013) and Burstein, Morales and Vogel (2015)
   - Educational choice based on individual comparative advantage and local labor market conditions
2. A Ricardian trade model
   - Extension of Eaton and Kortum (2002) and Costinot, Donaldson and Komunjer (2012)
   - Sectors $k = \{1, ..., K\}$, Factors $\{H, L\}$: different skill intensities
   - Regions $i, j \in \{1, ..., N\}$: different comparative advantage
   - Heckscher-Ohlin forces: between-sector reallocation

▸ Model

# Export Demand Shocks to Regional Markets

## Export Demand Shocks: from National to Local

- **i** is a small region in China; **j** is a region in the ROW
- Exogenous shocks to iceberg cost ($\{\hat{\tau}_{ij,k}\}$) and productivity ($\{\hat{\psi}_{i,k}\}$)
- Assume
  - $i$ is a small open economy
  - $\hat{\tau}_{ij,k} = \hat{\tau}_{j,k} + \hat{\hat{\tau}}_{ij,k}$, if $i \in$ China and $j \in ROW$

$$\begin{cases} \hat{\tau}_{j,k} : \text{changes in tariffs, exchange rates, etc.} \\ \hat{\hat{\tau}}_{ij,k} : \text{changes in transportation infrastructure} \end{cases}$$

  - $\hat{\tau}_{ii',k} = 0$, if $i, i' \in$ China

# Export Demand Shocks to Regional Markets

## Export Demand Shocks: from National to Local

- Log-linearizing equilibrium equations

$$\hat{\pi}_{i,h} = - c_{i,1} \underbrace{\sum_k h_{i,k} \sum_{j \in ROW} \gamma_{ij,k}(1-\lambda_{ij,k})\hat{\tau}_{j,k}}_{\text{High-Skill Shock}} + c_{i,2} \underbrace{\sum_k l_{i,k} \sum_{j \in ROW} \gamma_{ij,k}(1-\lambda_{ij,k})\hat{\tau}_{j,k}}_{\text{Low-Skill Shock}} + u(\{\hat{\psi}_{i,k}, \hat{\tilde{\tau}}_{ij,k}\})$$

where $c_{i,1}, c_{i,2} > 0$;

$h_{i,k} = \frac{H_{i,k}}{H_i}$ and $l_{i,k} = \frac{L_{i,k}}{L_i}$; $\gamma_{ij,k} = \frac{X_{ij,k}}{Y_{i,k}}$; $\lambda_{ijt,k} = \frac{X_{ijk}}{\sum_{i'} X_{i'jk}}$

# Export Demand Shocks to Regional Markets

## Export Demand Shocks: from National to Local

Correlation

- Assume
  - $c_{i,1} = c_1$ and $c_{i,2} = c_2$
  - $\frac{X_{i\ ROW,k}}{X_{CH\ ROW,k}} \approx \frac{E_{i,k}}{E_k}$, i.e. export share≈employment share (Analogous to Autor et al. (2013) and Gosta et al. (2016))
  - $\lambda_{ij,k} \approx 0$, i.e. $i$ has a small market share in $j$ of the ROW

- Reduced-form relationship

$$\hat{\pi}_{i,h} \approx \tilde{c}_1 \overbrace{\sum_k \underbrace{\frac{H_{i,k}}{E_{i,k}}}_{\text{Skill Intensity}} \underbrace{\frac{E_{i,k}}{E_k}}_{\text{Empl. Share}} \frac{\Delta X_k}{H_i}}^{\substack{\text{Emprical High-Skill Shock} \\ \Delta Export^H}} - \tilde{c}_2 \overbrace{\sum_k \frac{L_{i,k}}{E_{i,k}} \frac{E_{i,k}}{E_k} \frac{\Delta X_k}{L_i}}^{\substack{\text{Emprical Low-Skill Shock} \\ \Delta Export^L}} + u(\{\hat{\psi}_{i,k}, \hat{\tilde{\tau}}_{ij,k}\})$$

where $\Delta X_k \propto -\sum_{j \in ROW} X_{CHj,k} \hat{\tau}_{j,k}$

# Data

- China Population Censuses
  - 1% of 1990 Census; 1% of 2000 Census
  - 20% of 2005 1% Population Sampling Survey
  - Published aggregated data of 2010 Census
- High-skill: college or above; Low-skill: high school or below
- Trade data
  - Exports/Imports at 4-digit ISIC: UN Comtrade (2005 US$)
  - Export/Import tariffs at 4-digit ISIC: TRAINS
- Industry employment and trade data are mapped to 3-digit China's Industry Classification. (195 industries in the tradable sector)
- Other data sources: China Industrial Annual Survey and various Statistical Yearbooks

# Data

- Local labor market: 340 Prefectures
  - An administrative division ranking between province and county. Composed of both urban and rural areas.
  - Area and population of the median prefecture: 13,152 $km^2$ and 3.2 million (Greater Toronto: 7,124 $km^2$ and 6.1 million)
- Migration
  - Household registration system
  - Flow costs of inter-province of migration: 94%-98% of annual income in 2000, and 88%-97% in 2005. (Tombe and Zhu, 2015)
  - Five-year cross-prefecture migration rates (age 16-56) are 4.5% in 2000 and 4.8% in 2005. The 2005 migration rate translates into a cross-prefecture migration flow of 38.76 million.

# Data

- Migration
  - Tombe and Zhu (2015): stock of inter-provincial migrants increased from 26.5 to 49 million over 2000 to 2005, suggesting a flow of 22.5 million migrants.
  - Cheng and Potlogea (2015): most migration in response to trade liberalization takes place within prefectures
  - US, 1990-2005: cross-state migration rate is 2.5% each year (Kaplan and Schulhofer-Wohl, 2013). India, 2007: cross-district migration rate is 2.7% each year (Marden,2015)
- The 2000 and 2005 population censuses: information on prefecture of residence before migration. I will use this data to investigate selective migration and potential confounding effects introduced.

# Data

## Export Demand Shocks: from Model to Data

- To construct the empirical counterpart of $\Delta X_k$

$$\ln Export_{kt} = \beta \ln(Tariff^X_{kt}) + \gamma_k + \phi_t + \mu_{kt}$$

$$-0.204^{***}(0.039)$$

where $Tariff^X_{kt} = \sum_j \frac{Export_{CH,j,k,t-3}}{Export_{CH,j,t-3}} Tariff_{jkt}$

- 2000-05: $\Delta \ln(Tariff^X_{kt})$ is uncorrelated with $\Delta \ln(VAperWorker_{kt})$

- The exogenous export demand shocks

$$\Delta Export^H_{it} = \sum_k \frac{H_{ik0}}{E_{ik0}} \frac{E_{ik0}}{E_{k0}} \frac{\Delta \widehat{Export}_{kt}}{H_{i0}}$$

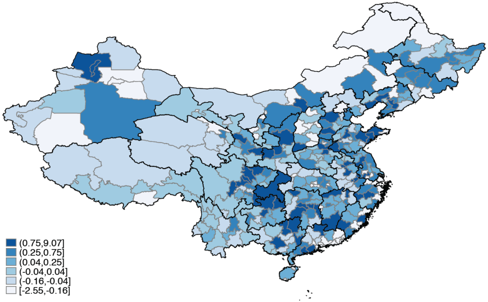
$$\Delta Export^L_{it} = \sum_k \frac{L_{ik0}}{E_{ik0}} \frac{E_{ik0}}{E_{k0}} \frac{\Delta \widehat{Export}_{kt}}{L_{i0}}$$

# Data

## Export Demand Shocks: from Model to Data

Export Shocks (1000USD)

| | mean | std | $10^{th}$ | $25^{th}$ | $50^{th}$ | $75^{th}$ | $90^{th}$ |
|---|---|---|---|---|---|---|---|
| $\Delta Export^L$, 90-00 | 0.119 | 0.145 | 0.010 | 0.032 | 0.066 | 0.144 | 0.309 |
| $\Delta Export^H$, 90-00 | 0.197 | 0.280 | 0.000 | 0.019 | 0.103 | 0.289 | 0.487 |
| $\Delta Export^L$, 00-05 | 0.517 | 0.629 | 0.044 | 0.141 | 0.294 | 0.622 | 1.346 |
| $\Delta Export^H$, 00-05 | 0.842 | 1.169 | 0.001 | 0.082 | 0.441 | 1.229 | 2.057 |




Differential Export Shocks: 2000-2005

# Data

- Nine-year compulsory schooling in China:
  - In effect in 1986. It requires all the children to attend school by the age of 7
  - Imperfect enforcement, especially for the junior secondary education
- Focus on young people who are not subject to the compulsory schooling figure
  - Aged 16 to 18, high school
  - Aged 19 to 22, college

# Effects of Export Expansion on School Enrollments

Baseline Regression

$$\Delta Enroll_{it} = \beta_L \Delta Export^L_{it} + \beta_H \Delta Export^H_{it} + \phi_{pt} + \varepsilon_{it}$$

- $\phi_{pt}$: province×year dummies
- Weighted by the start of the period age-group population
- All standard errors are clustered at the province level
- Augmented with demographic and socioeconomic controls:
  - Δ average age; Δ sex ratio; Δ share of Han ethnic group
  - Δ share pop with urban residence status
  - Δ log GDP per capita; Δ log fiscal expenditure on education
  - Initial conditions: start of the period enrollment rate and GDP per capita

# Effects of Export Expansion on School Enrollments

- Prefecture-specific pre-determined trend may be correlated with initial industry composition.
- Additional controls:

$$PHI_{i0} = \sum_{k \in Tr} \frac{H_{ik0}}{E_{ik0}} \frac{E_{ik0}}{E_{i0}} \quad \text{and} \quad PLI_{i0} = \sum_{k \in Tr} \frac{L_{ik0}}{E_{ik0}} \frac{E_{ik0}}{E_{i0}}$$

- $PHI_{i0} + PLI_{i0} =$ Empl. Share in Tradable Sector
- Isolate the variation of export demand shocks stemming from the difference in within-tradable sector industry composition
- Capture a region's initial skill intensity

| | $\Delta Enroll$ |
|---|---|
| | (1) |
| **Panel A: Age 16-18** | |
| $\Delta Export^L$ | -0.058*** |
| | (0.014) |
| $\Delta Export^H$ | 0.008*** |
| | (0.002) |
| Province×Year | Y |
| Controls | |
| Initial Conditions | |
| $PHI$ and $PLI$ | |
| Prefecture | |
| $N$ | 680 |
| $R^2$ | 0.399 |
| **Panel B: Age 19-22** | |
| $\Delta Export^L$ | -0.021*** |
| | (0.003) |
| $\Delta Export^H$ | 0.012*** |
| | (0.002) |
| Province×Year | Y |
| Controls | |
| Initial Conditions | |
| $PHI$ and $PLI$ | |
| Prefecture | |
| $N$ | 680 |
| $R^2$ | 0.145 |

*** p<0.01, ** p<0.05, * p<0.1

| | $\Delta Enroll$ | $\Delta Enroll$ | $\Delta Enroll$ |
|---|---|---|---|
| | (1) | (2) | (3) |
| **Panel A: Age 16-18** | | | |
| $\Delta Export^L$ | -0.058*** | -0.051*** | -0.024** |
| | (0.014) | (0.008) | (0.009) |
| $\Delta Export^H$ | 0.008*** | 0.007*** | 0.006*** |
| | (0.002) | (0.002) | (0.002) |
| Province×Year | Y | Y | Y |
| Controls | | Y | Y |
| Initial Conditions | | | Y |
| $PHI$ and $PLI$ | | | |
| Prefecture | | | |
| $N$ | 680 | 673 | 673 |
| $R^2$ | 0.399 | 0.644 | 0.681 |
| **Panel B: Age 19-22** | | | |
| $\Delta Export^L$ | -0.021*** | -0.021*** | -0.019*** |
| | (0.003) | (0.005) | (0.004) |
| $\Delta Export^H$ | 0.012*** | 0.010*** | 0.010*** |
| | (0.002) | (0.002) | (0.002) |
| Province×Year | Y | Y | Y |
| Controls | | Y | Y |
| Initial Conditions | | | Y |
| $PHI$ and $PLI$ | | | |
| Prefecture | | | |
| $N$ | 680 | 673 | 673 |
| $R^2$ | 0.145 | 0.597 | 0.695 |

*** p<0.01, ** p<0.05, * p<0.1

| | $\Delta Enroll$ | $\Delta Enroll$ | $\Delta Enroll$ | $\Delta Enroll$ |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| **Panel A: Age 16-18** | | | | |
| $\Delta Export^L$ | -0.058*** | -0.051*** | -0.024** | -0.034*** |
| | (0.014) | (0.008) | (0.009) | (0.011) |
| $\Delta Export^H$ | 0.008*** | 0.007*** | 0.006*** | 0.005** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Province×Year | Y | Y | Y | Y |
| Controls | | Y | Y | Y |
| Initial Conditions | | | Y | Y |
| $PHI$ and $PLI$ | | | | Y |
| Prefecture | | | | |
| $N$ | 680 | 673 | 673 | 673 |
| $R^2$ | 0.399 | 0.644 | 0.681 | 0.693 |
| **Panel B: Age 19-22** | | | | |
| $\Delta Export^L$ | -0.021*** | -0.021*** | -0.019*** | -0.031*** |
| | (0.003) | (0.005) | (0.004) | (0.005) |
| $\Delta Export^H$ | 0.012*** | 0.010*** | 0.010*** | 0.007*** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Province×Year | Y | Y | Y | Y |
| Controls | | Y | Y | Y |
| Initial Conditions | | | Y | Y |
| $PHI$ and $PLI$ | | | | Y |
| Prefecture | | | | |
| $N$ | 680 | 673 | 673 | 673 |
| $R^2$ | 0.145 | 0.597 | 0.695 | 0.761 |

*** p<0.01, ** p<0.05, * p<0.1

| | $\Delta Enroll$ | $\Delta Enroll$ | $\Delta Enroll$ | $\Delta Enroll$ | $\Delta Enroll$ |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| **Panel A: Age 16-18** | | | | | |
| $\Delta Export^L$ | -0.058*** | -0.051*** | -0.024** | -0.034*** | -0.058** |
| | (0.014) | (0.008) | (0.009) | (0.011) | (0.028) |
| $\Delta Export^H$ | 0.008*** | 0.007*** | 0.006*** | 0.005** | 0.009** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.003) |
| Province×Year | Y | Y | Y | Y | Y |
| Controls | | Y | Y | Y | Y |
| Initial Conditions | | | Y | Y | Y |
| $PHI$ and $PLI$ | | | | Y | |
| Prefecture | | | | | Y |
| $N$ | 680 | 673 | 673 | 673 | 673 |
| $R^2$ | 0.399 | 0.644 | 0.681 | 0.693 | 0.924 |
| **Panel B: Age 19-22** | | | | | |
| $\Delta Export^L$ | -0.021*** | -0.021*** | -0.019*** | -0.031*** | -0.039** |
| | (0.003) | (0.005) | (0.004) | (0.005) | (0.015) |
| $\Delta Export^H$ | 0.012*** | 0.010*** | 0.010*** | 0.007*** | 0.010** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.005) |
| Province×Year | Y | Y | Y | Y | Y |
| Controls | | Y | Y | Y | Y |
| Initial Conditions | | | Y | Y | Y |
| $PHI$ and $PLI$ | | | | Y | |
| Prefecture | | | | | Y |
| $N$ | 680 | 673 | 673 | 673 | 673 |
| $R^2$ | 0.145 | 0.597 | 0.695 | 0.761 | 0.920 |

*** p<0.01, ** p<0.05, * p<0.1

| | $\Delta Enroll$ | $\Delta Enroll$ | $\Delta Enroll$ | $\Delta Enroll$ | $\Delta Enroll$ | $\Delta Highsch./$ $\Delta College$ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Panel A: Age 16-18** | | | | | | |
| $\Delta Export^L$ | -0.058*** | -0.051*** | -0.024** | -0.034*** | -0.058** | -0.019* |
| | (0.014) | (0.008) | (0.009) | (0.011) | (0.028) | (0.009) |
| $\Delta Export^H$ | 0.008*** | 0.007*** | 0.006*** | 0.005** | 0.009** | 0.009*** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.003) | (0.002) |
| Province×Year | Y | Y | Y | Y | Y | Y |
| Controls | | Y | Y | Y | Y | Y |
| Initial Conditions | | | Y | Y | Y | Y |
| $PHI$ and $PLI$ | | | | Y | | Y |
| Prefecture | | | | | Y | |
| $N$ | 680 | 673 | 673 | 673 | 673 | 673 |
| $R^2$ | 0.399 | 0.644 | 0.681 | 0.693 | 0.924 | 0.857 |
| **Panel B: Age 19-22** | | | | | | |
| $\Delta Export^L$ | -0.021*** | -0.021*** | -0.019*** | -0.031*** | -0.039** | -0.023*** |
| | (0.003) | (0.005) | (0.004) | (0.005) | (0.015) | (0.002) |
| $\Delta Export^H$ | 0.012*** | 0.010*** | 0.010*** | 0.007*** | 0.010** | 0.004** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.005) | (0.002) |
| Province×Year | Y | Y | Y | Y | Y | Y |
| Controls | | Y | Y | Y | Y | Y |
| Initial Conditions | | | Y | Y | Y | Y |
| $PHI$ and $PLI$ | | | | Y | | Y |
| Prefecture | | | | | Y | |
| $N$ | 680 | 673 | 673 | 673 | 673 | 673 |
| $R^2$ | 0.145 | 0.597 | 0.695 | 0.761 | 0.920 | 0.770 |

*** p<0.01, ** p<0.05, * p<0.1

# Effects of Export Expansion on School Enrollments

## Robustness: Non-local Export Shocks

- Responses to export expansions in other prefectures
- To address the problem
  1) Weighted average of neighboring prefectures' export shocks

$$\Delta Export_{it}^{s,N} = \sum_{r \in Neighbor_i} \theta_{ir} \Delta Export_{rt}^{s}$$

where $\theta_{ir} = \frac{E_{r0}}{\sum_{r' \in Neighbor_i} E_{r'0}}$.

  2) Weighted average of all other prefectures' export expansions

$$\Delta Export_{it}^{s,N} = \sum_{r \neq i} \frac{1}{d_{ir}} \Delta Export_{rt}^{s}$$

where $d_{ir}$ is the distance between $i$ and $r$.
(Similar results when using migration flows as weights.)

| | (a) Neighbor Prefectures | | (b) All Other Prefectures | |
|---|---|---|---|---|
| | Age 16-18 | Age 19-22 | Age 16-18 | Age 19-22 |
| | (1) | (2) | (3) | (4) |
| $\Delta Export^{L}$ | -0.034*** | -0.032*** | -0.031*** | -0.029*** |
| | (0.010) | (0.004) | (0.010) | (0.005) |
| $\Delta Export^{H}$ | 0.006*** | 0.007*** | 0.008*** | 0.008*** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| $\Delta Export^{L,N}$ | -0.004 | -0.005*** | -0.053** | -0.031*** |
| | (0.003) | (0.001) | (0.023) | (0.010) |
| $\Delta Export^{H,N}$ | 0.001 | -0.000 | 0.037** | 0.017*** |
| | (0.001) | (0.001) | (0.014) | (0.006) |
| Province×Year | Y | Y | Y | Y |
| Controls | Y | Y | Y | Y |
| Initial Conditions | Y | Y | Y | Y |
| $PHI$ and $PLI$ | Y | Y | Y | Y |
| $N$ | 673 | 673 | 673 | 673 |
| $R^2$ | 0.695 | 0.767 | 0.703 | 0.764 |

*** p<0.01, ** p<0.05, * p<0.1

| | (a) Neighbor Prefectures | | (b) All Other Prefectures | |
|---|---|---|---|---|
| | Age 16-18 | Age 19-22 | Age 16-18 | Age 19-22 |
| | (1) | (2) | (3) | (4) |
| $\Delta Export^{L}$ | -0.034*** | -0.032*** | -0.031*** | -0.029*** |
| | (0.010) | (0.004) | (0.010) | (0.005) |
| $\Delta Export^{H}$ | 0.006*** | 0.007*** | 0.008*** | 0.008*** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| $\Delta Export^{L,N}$ | -0.004 | -0.005*** | -0.053** | -0.031*** |
| | (0.003) | (0.001) | (0.023) | (0.010) |
| $\Delta Export^{H,N}$ | 0.001 | -0.000 | 0.037** | 0.017*** |
| | (0.001) | (0.001) | (0.014) | (0.006) |
| Province×Year | Y | Y | Y | Y |
| Controls | Y | Y | Y | Y |
| Initial Conditions | Y | Y | Y | Y |
| $PHI$ and $PLI$ | Y | Y | Y | Y |
| $N$ | 673 | 673 | 673 | 673 |
| $R^2$ | 0.695 | 0.767 | 0.703 | 0.764 |

*** p<0.01, ** p<0.05, * p<0.1

# Effects of Export Expansion on School Enrollments

## Robustness: Import Shocks

- Focus on export expansion so far because of its cleaner channel and plausible exogeneity
- Import could affect educational choice through different channels:
  - Import competition: $\Delta Import^{L}$ and $\Delta Import^{H}$
  - Complementarity or substitutability of imported intermediary and capital goods: $\Delta Import^{L,CI}$ and $\Delta Import^{H,CI}$
- Import tariff could be endogenous

| | Age 16-18 | | | Age 19-22 | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\Delta Export^L$ | -0.027*** | -0.036*** | -0.023*** | -0.023*** | -0.033*** | -0.033*** |
| | (0.009) | (0.012) | (0.007) | (0.004) | (0.005) | (0.007) |
| $\Delta Export^H$ | 0.007*** | 0.006** | 0.006** | 0.011*** | 0.008*** | 0.009*** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| $\Delta Import^L$ | 0.011* | 0.007 | 0.015** | 0.017* | 0.008* | 0.008* |
| | (0.006) | (0.007) | (0.006) | (0.009) | (0.004) | (0.005) |
| $\Delta Import^H$ | -0.002*** | -0.001** | -0.002*** | -0.002** | -0.001** | -0.001*** |
| | (0.001) | (0.001) | (0.000) | (0.001) | (0.000) | (0.000) |
| $\Delta Import^{L,CI}$ | | | -0.054*** | | | -0.016 |
| | | | (0.012) | | | (0.016) |
| $\Delta Import^{H,CI}$ | | | 0.001 | | | -0.001 |
| | | | (0.003) | | | (0.003) |
| Province×Year | Y | Y | Y | Y | Y | Y |
| Controls | Y | Y | Y | Y | Y | Y |
| Initial Conditions | Y | Y | Y | Y | Y | Y |
| *PHI* and *PLI* | | Y | Y | | Y | Y |
| $N$ | 673 | 673 | 673 | 673 | 673 | 673 |
| $R^2$ | 0.682 | 0.693 | 0.698 | 0.697 | 0.762 | 0.762 |

*** p<0.01, ** p<0.05, * p<0.1

| | Age 16-18 | | | Age 19-22 | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\Delta Export^L$ | -0.027*** | -0.036*** | -0.023*** | -0.023*** | -0.033*** | -0.033*** |
| | (0.009) | (0.012) | (0.007) | (0.004) | (0.005) | (0.007) |
| $\Delta Export^H$ | 0.007*** | 0.006** | 0.006** | 0.011*** | 0.008*** | 0.009*** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| $\Delta Import^L$ | 0.011* | 0.007 | 0.015** | 0.017* | 0.008* | 0.008* |
| | (0.006) | (0.007) | (0.006) | (0.009) | (0.004) | (0.005) |
| $\Delta Import^H$ | -0.002*** | -0.001** | -0.002*** | -0.002** | -0.001** | -0.001*** |
| | (0.001) | (0.001) | (0.000) | (0.001) | (0.000) | (0.000) |
| $\Delta Import^{L,CI}$ | | | -0.054*** | | | -0.016 |
| | | | (0.012) | | | (0.016) |
| $\Delta Import^{H,CI}$ | | | 0.001 | | | -0.001 |
| | | | (0.003) | | | (0.003) |
| Province×Year | Y | Y | Y | Y | Y | Y |
| Controls | Y | Y | Y | Y | Y | Y |
| Initial Conditions | Y | Y | Y | Y | Y | Y |
| $PHI$ and $PLI$ | | Y | Y | | Y | Y |
| $N$ | 673 | 673 | 673 | 673 | 673 | 673 |
| $R^2$ | 0.682 | 0.693 | 0.698 | 0.697 | 0.762 | 0.762 |

*** p<0.01, ** p<0.05, * p<0.1

| | Age 16-18 | | | Age 19-22 | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\Delta Export^L$ | -0.027*** | -0.036*** | -0.023*** | -0.023*** | -0.033*** | -0.033*** |
| | (0.009) | (0.012) | (0.007) | (0.004) | (0.005) | (0.007) |
| $\Delta Export^H$ | 0.007*** | 0.006** | 0.006** | 0.011*** | 0.008*** | 0.009*** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| $\Delta Import^L$ | 0.011* | 0.007 | 0.015** | 0.017* | 0.008* | 0.008* |
| | (0.006) | (0.007) | (0.006) | (0.009) | (0.004) | (0.005) |
| $\Delta Import^H$ | -0.002*** | -0.001** | -0.002*** | -0.002** | -0.001** | -0.001*** |
| | (0.001) | (0.001) | (0.000) | (0.001) | (0.000) | (0.000) |
| $\Delta Import^{L,CI}$ | | | -0.054*** | | | -0.016 |
| | | | (0.012) | | | (0.016) |
| $\Delta Import^{H,CI}$ | | | 0.001 | | | -0.001 |
| | | | (0.003) | | | (0.003) |
| Province×Year | Y | Y | Y | Y | Y | Y |
| Controls | Y | Y | Y | Y | Y | Y |
| Initial Conditions | Y | Y | Y | Y | Y | Y |
| $PHI$ and $PLI$ | | Y | Y | | Y | Y |
| $N$ | 673 | 673 | 673 | 673 | 673 | 673 |
| $R^2$ | 0.682 | 0.693 | 0.698 | 0.697 | 0.762 | 0.762 |

*** p<0.01, ** p<0.05, * p<0.1

# Effects of Export Expansion on School Enrollments

## Robustness: Migration

- Selective Migration
  - Low-skill export expansion $\downarrow$ average education of immigrants and $\uparrow$ average education of out-migrants
  - High-skill export expansion $\uparrow$ average education of immigrants and $\downarrow$ average education of out-migrants
- Effects of export shocks on selection migration

$$\Delta y_{it} = \theta_L \Delta Export_{it}^{L} + \theta_H \Delta Export_{it}^{H} + \phi_p + \varepsilon_{it}$$

  - $y_{it}$: immigration (emigration) rate of low-skilled (high-skilled) workers; ratio of inflow to outflow of low-skilled (high-skilled) workers.

| | $\Delta IMR^L$ | $\Delta IMR^H$ | $\Delta EMR^L$ | $\Delta EMR^H$ | $\Delta \frac{IM^L}{EM^L}$ | $\Delta \frac{IM^H}{EM^H}$ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\Delta Export^L$ | 0.020*** | -0.020** | -0.006** | 0.032*** | 29.428** | 0.154 |
| | (0.005) | (0.010) | (0.003) | (0.007) | (12.321) | (0.402) |
| $\Delta Export^H$ | -0.002* | -0.005 | 0.002 | 0.000 | -2.954* | -0.076 |
| | (0.001) | (0.003) | (0.001) | (0.002) | (1.593) | (0.047) |
| Province | Y | Y | Y | Y | Y | Y |
| $N$ | 340 | 340 | 340 | 340 | 340 | 340 |
| $R^2$ | 0.471 | 0.573 | 0.626 | 0.485 | 0.535 | 0.614 |

*** p<0.01, ** p<0.05, * p<0.1

# Effects of Export Expansion on School Enrollments

## Robustness: Migration

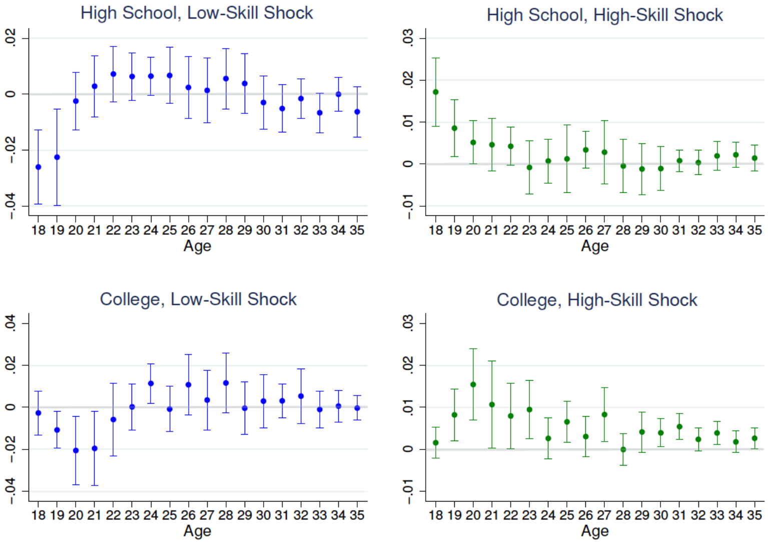
- The bias introduced by selective migration is *a priori* ambiguous, because it
  - alters the composition of young workers $\implies$ overstate the true effect
  - shifts the relative skill supply and dampens the effect of trade induced changes in relative skill demand $\implies$ understate the true effect
- To evaluate the potential bias:
  - Alternative samples: non-migrants
  - Falsification Test: Effects of export shocks on the educational attainments of older age groups
- Students could attend a college outside their home prefecture: robust results to the sample of non-migrants and out-migrants

| | Age 16-18 | | Age 19-22 | | |
|---|---|---|---|---|---|
| | $\Delta Enroll$ All | $\Delta Enroll$ Non-migrants | $\Delta Enroll$ All | $\Delta Enroll$ Non-migrants | $\Delta Enroll$ Non-migrants & Out-migrants |
| | (1) | (2) | (3) | (4) | (5) |
| $\Delta Export^{LS}$ | -0.029** | -0.019* | -0.027*** | -0.013* | -0.013** |
| | (0.012) | (0.011) | (0.006) | (0.008) | (0.06) |
| $\Delta Export^{HS}$ | 0.004** | 0.006*** | 0.006*** | 0.004** | 0.003** |
| | (0.002) | (0.001) | (0.002) | (0.002) | (0.001) |
| Province | Y | Y | Y | Y | Y |
| Controls | Y | Y | Y | Y | Y |
| Initial Conditions | Y | Y | Y | Y | Y |
| $PHI$ and $PLI$ | Y | Y | Y | Y | Y |
| $N$ | 340 | 340 | 340 | 340 | 340 |
| $R^2$ | 0.694 | 0.633 | 0.662 | 0.703 | 0.687 |

*** p<0.01, ** p<0.05, * p<0.1

| | Age 16-18 | | Age 19-22 | | |
|---|---|---|---|---|---|
| | $\Delta Enroll$ All | $\Delta Enroll$ Non-migrants | $\Delta Enroll$ All | $\Delta Enroll$ Non-migrants | $\Delta Enroll$ Non-migrants & Out-migrants |
| | (1) | (2) | (3) | (4) | (5) |
| $\Delta Export^{LS}$ | -0.029** | -0.019* | -0.027*** | -0.013* | -0.013** |
| | (0.012) | (0.011) | (0.006) | (0.008) | (0.06) |
| $\Delta Export^{HS}$ | 0.004** | 0.006*** | 0.006*** | 0.004** | 0.003** |
| | (0.002) | (0.001) | (0.002) | (0.002) | (0.001) |
| Province | Y | Y | Y | Y | Y |
| Controls | Y | Y | Y | Y | Y |
| Initial Conditions | Y | Y | Y | Y | Y |
| $PHI$ and $PLI$ | Y | Y | Y | Y | Y |
| $N$ | 340 | 340 | 340 | 340 | 340 |
| $R^2$ | 0.694 | 0.633 | 0.662 | 0.703 | 0.687 |

*** p<0.01, ** p<0.05, * p<0.1



High School, Low-Skill Shock
High School, High-Skill Shock
College, Low-Skill Shock
College, High-Skill Shock
Age
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
.04
.03
.02
.01
0
-.01
-.02
-.04

# Effects of Export Expansion on School Enrollments

## Robustness

Robust and Consistent Results:

- Effects of export shocks on education provision ▸ supply
- Hetero. effects: Boys vs Girls, Urban vs Rural ▸ hetero
- Dropping one province/two provinces at a time ▸ drop
- More disaggregated export shocks ▸ disaggregate
- Ages under compulsory schooling ▸ compulsory
- Labor market outcomes ▸ other
- Foreign direct investment ▸ FDI

# Effects of Change in Skill Supply on Industry Specialization

- The youth aged 16 to 22 in 2000 had already entered the labor market by 2010, shifting the skill supply of the local labor market
- Whether endogenous change in skill supply reinforces the industry specialization? Linking
  - $\Delta$ Employment shares during 2000-2010
  - $\Delta$ School Enrollment in 1990-2000
- Instrumenting $\Delta Enroll_{t-1}$ with $\Delta Export^{L}_{it-1}$ and $\Delta Export^{H}_{it-1}$

# Effects of Change in Skill Supply on Industry Specialization

$$\Delta Share^{Manuf.}_{ikt} = \sum_{K\in\{L,M,H\}} \theta_K \mathbf{1}(k \in K)\Delta HighSch.Enroll_{it-1} + \sum_{K\in\{L,M,H\}} \delta_K \mathbf{1}(k \in K)\Delta CollegeEnroll_{it-1} + \boldsymbol{X}'_{\boldsymbol{ik,t}}\zeta + \psi_{pk} + \upsilon_{ikt}$$

- $Share^{Manuf.}_{ikt}$: industry $k$ 's share in the manufacturing employment of prefecture $i$
- $\boldsymbol{X}_{\boldsymbol{ik,t}}$: $Share^{Manuf.}_{ikt-1}$ and $\Delta Share^{Manuf.}_{ikt-1}$
- $\psi_{pk}$: Province×Industry dummies
- Differential effects: $\theta_K$ and $\delta_K$
- All standard errors are clustered at the prefecture level

alternative

| | $\Delta Share^{Manuf.}$ | | | | $\Delta Share$ | |
|---|---|---|---|---|---|---|
| | Employment | | Output | | Employment | |
| | OLS | 2SLS | OLS | 2SLS | OLS | 2SLS |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $L \times \Delta HighSch.Enroll_{t-1}$ | 0.025*** | 0.132*** | -0.003 | 0.153 | 0.012*** | 0.080*** |
| | (0.007) | (0.050) | (0.012) | (0.098) | (0.003) | (0.029) |
| $M \times \Delta HighSch.Enroll_{t-1}$ | -0.010 | -0.020 | -0.008 | -0.078 | 0.001 | 0.017* |
| | (0.007) | (0.030) | (0.010) | (0.100) | (0.001) | (0.010) |
| $H \times \Delta HighSch.Enroll_{t-1}$ | -0.015** | -0.113** | 0.013 | -0.069 | -0.003 | -0.025** |
| | (0.006) | (0.046) | (0.011) | (0.092) | (0.002) | (0.012) |
| $L \times \Delta College.Enroll_{t-1}$ | -0.022*** | -0.087*** | -0.006 | -0.088* | -0.009*** | -0.063*** |
| | (0.008) | (0.034) | (0.008) | (0.050) | (0.002) | (0.019) |
| $M \times \Delta College.Enroll_{t-1}$ | 0.008 | 0.009 | 0.007 | 0.010 | -0.002* | -0.020*** |
| | (0.006) | (0.018) | (0.009) | (0.053) | (0.001) | (0.007) |
| $H \times \Delta College.Enroll_{t-1}$ | 0.013** | 0.078*** | 0.001 | 0.079* | -0.000 | 0.015* |
| | (0.006) | (0.030) | (0.011) | (0.042) | (0.002) | (0.009) |
| $\Delta ShareEmp^{Manuf.}_{t-1}$ | Y | Y | Y | Y | | |
| $\Delta ShareEmp_{t-1}$ | | | | | Y | Y |
| Province×Ind | Y | Y | Y | Y | Y | Y |
| N | 8,721 | 8,721 | 9,180 | 9,180 | 8,721 | 8,721 |

*** p<0.01, ** p<0.05, * p<0.1

| | $\Delta Share^{Manuf.}$ | | | | $\Delta Share$ | |
|---|---|---|---|---|---|---|
| | Employment | | Output | | Employment | |
| | OLS | 2SLS | OLS | 2SLS | OLS | 2SLS |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $L \times \Delta HighSch.Enroll_{t-1}$ | 0.025*** | 0.132*** | -0.003 | 0.153 | 0.012*** | 0.080*** |
| | (0.007) | (0.050) | (0.012) | (0.098) | (0.003) | (0.029) |
| $M \times \Delta HighSch.Enroll_{t-1}$ | -0.010 | -0.020 | -0.008 | -0.078 | 0.001 | 0.017* |
| | (0.007) | (0.030) | (0.010) | (0.100) | (0.001) | (0.010) |
| $H \times \Delta HighSch.Enroll_{t-1}$ | -0.015** | -0.113** | 0.013 | -0.069 | -0.003 | -0.025** |
| | (0.006) | (0.046) | (0.011) | (0.092) | (0.002) | (0.012) |
| $L \times \Delta College.Enroll_{t-1}$ | -0.022*** | -0.087*** | -0.006 | -0.088* | -0.009*** | -0.063*** |
| | (0.008) | (0.034) | (0.008) | (0.050) | (0.002) | (0.019) |
| $M \times \Delta College.Enroll_{t-1}$ | 0.008 | 0.009 | 0.007 | 0.010 | -0.002* | -0.020*** |
| | (0.006) | (0.018) | (0.009) | (0.053) | (0.001) | (0.007) |
| $H \times \Delta College.Enroll_{t-1}$ | 0.013** | 0.078*** | 0.001 | 0.079* | -0.000 | 0.015* |
| | (0.006) | (0.030) | (0.011) | (0.042) | (0.002) | (0.009) |
| $\Delta ShareEmp^{Manuf.}_{t-1}$ | Y | Y | Y | Y | | |
| $\Delta ShareEmp_{t-1}$ | | | | | Y | Y |
| Province×Ind | Y | Y | Y | Y | Y | Y |
| N | 8,721 | 8,721 | 9,180 | 9,180 | 8,721 | 8,721 |

*** p<0.01, ** p<0.05, * p<0.1

| | $\Delta Share^{Manuf.}$ | | | | $\Delta Share$ | |
|---|---|---|---|---|---|---|
| | Employment | | Output | | Employment | |
| | OLS | 2SLS | OLS | 2SLS | OLS | 2SLS |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $L \times \Delta HighSch.Enroll_{t-1}$ | 0.025*** | 0.132*** | -0.003 | 0.153 | 0.012*** | 0.080*** |
| | (0.007) | (0.050) | (0.012) | (0.098) | (0.003) | (0.029) |
| $M \times \Delta HighSch.Enroll_{t-1}$ | -0.010 | -0.020 | -0.008 | -0.078 | 0.001 | 0.017* |
| | (0.007) | (0.030) | (0.010) | (0.100) | (0.001) | (0.010) |
| $H \times \Delta HighSch.Enroll_{t-1}$ | -0.015** | -0.113** | 0.013 | -0.069 | -0.003 | -0.025** |
| | (0.006) | (0.046) | (0.011) | (0.092) | (0.002) | (0.012) |
| $L \times \Delta College.Enroll_{t-1}$ | -0.022*** | -0.087*** | -0.006 | -0.088* | -0.009*** | -0.063*** |
| | (0.008) | (0.034) | (0.008) | (0.050) | (0.002) | (0.019) |
| $M \times \Delta College.Enroll_{t-1}$ | 0.008 | 0.009 | 0.007 | 0.010 | -0.002* | -0.020*** |
| | (0.006) | (0.018) | (0.009) | (0.053) | (0.001) | (0.007) |
| $H \times \Delta College.Enroll_{t-1}$ | 0.013** | 0.078*** | 0.001 | 0.079* | -0.000 | 0.015* |
| | (0.006) | (0.030) | (0.011) | (0.042) | (0.002) | (0.009) |
| $\Delta ShareEmp^{Manuf.}_{t-1}$ | Y | Y | Y | Y | | |
| $\Delta ShareEmp_{t-1}$ | | | | | Y | Y |
| Province×Ind | Y | Y | Y | Y | Y | Y |
| N | 8,721 | 8,721 | 9,180 | 9,180 | 8,721 | 8,721 |

*** p<0.01, ** p<0.05, * p<0.1

# Conclusion

- Due to export expansion, prefectures initially specialized in high-skill industries experienced faster human capital accumulation relative to the regions initially specialized in low-skill industries.
- Trade-induced changes in skill supply reinforce the initial regional industry specialization.
- Further trade liberalization will accelerate regional divergence in education attainment and industry specialization in China.

# Appendix

# A Model with Endogenous Skill Supply

## Endogenous Skill Formation

- Heterogeneous workers
  - A unit mass are born at each unit of time; have a lifetime of $T$
  - Endowed with a vector of "individual productivities" $\{z_h, z_l\}$
  - $\{z_h, z_l\}$ are drawn from the multivariate Fréchet distribution governed by:
    - $\kappa$: dispersion of efficiency units
    - $\nu$: correlation between $z_h$ and $z_l$

Frechet

- Endogenous Skill Formation
  - At birth $\begin{cases} \text{Uneducated, } w_{i,l} z_l \\ \text{Spend } \varphi \text{ in school } \rightarrow \text{Educated, } w_{i,h} z_h \end{cases}$

# A Model with Endogenous Skill Supply

## Endogenous Skill Formation

- School enrollment rate $\pi_{i,h}$

$$\pi_{i,h} = Prob(\underbrace{z_h w_{i,h}(e^{-r\varphi} - e^{-rT})/r}_{\substack{\text{Lifetime Income} \\ \text{Educated Workers}}} \geq \underbrace{z_l w_{i,l}(1 - e^{-rT})/r}_{\substack{\text{Lifetime Income} \\ \text{Uneducated Workers}}})$$

$$= \frac{1}{\mu_i^{-\kappa/(1-\nu)} + 1}$$

where $\mu_i = \frac{e^{-r\varphi} - e^{-rT}}{1 - e^{-rT}} \frac{w_{i,h}}{w_{i,l}}$ is the education return

- Endogenous skilled- and unskilled-labor supplies

$$H_i = (T - \varphi)\pi_{i,h}E(z_h|Educ) \text{ and } L_i = T(1 - \pi_{i,h})E(z_l|Uneduc)$$

# A Model with Endogenous Skill Supply

## Production

- Production
  - Each good $k$ may have an infinite number of varieties indexed by $\omega \in \Omega \equiv \{1, ..., +\infty\}$
  - Technology

$$y_{i,k}(\omega) = \psi_{i,k}(\omega) h_{i,k}(\omega)^{\alpha_k} l_{i,k}(\omega)^{1-\alpha_k}$$

    where $\alpha_1 > \alpha_2 > ... > \alpha_K$.
  - $\psi_{i,k}(\omega)$ is a random variable drawn independently from the Fréchet distribution

$$\Psi_{i,k}(\psi) = exp[-(\psi/\psi_{i,k})^{-\varepsilon}] \quad \text{with} \quad \varepsilon > 1$$

  - Variable production cost, $v_{i,k}(\omega) = \frac{1}{\psi_{i,k}(\omega)} \left(\frac{w_{i,h}}{\alpha_k}\right)^{\alpha_k} \left(\frac{w_{i,l}}{1-\alpha_k}\right)^{1-\alpha_k}$

# A Model with Endogenous Skill Supply

## Trade Cost, Market Structure and Preference

- Trade Cost
  - Iceberg cost, $\tau_{ij,k}$
  - Variable cost of selling to market $j$, $v_{i,k}(\omega)\tau_{ij,k}$
- Market Structure
  - Perfect Competition: $p_{ij,k}(\omega) = v_{i,k}(\omega)\tau_{ij,k}$
  - Shopping around the world

$$p_{j,k}(\omega) = \min_i \{p_{ij,k}(\omega)\}$$

- Preference: two-tier utility functions
  - Upper tier: $C_j = \prod_{k=1}^{K} C_{j,k}^{\beta_k}$
  - Lower tier: $C_{j,k}$ is a CES aggregate of varieties from different regions

# A Model with Endogenous Skill Supply

## Trade Flows and Trade Balance

- Share of region $j$'s consumption on good $k$ from region $i$

$$\lambda_{ij,k} = \frac{(v_{i,k}\tau_{ij,k})^{-\varepsilon}}{\sum_{i'}(v_{i',k}\tau_{i'j,k})^{-\varepsilon}}$$

where $v_{i,k} = \frac{1}{\psi_{i,k}}\left(\frac{w_{i,h}}{\alpha_k}\right)^{\alpha_k}\left(\frac{w_{i,l}}{1-\alpha_k}\right)^{1-\alpha_k}$

- Flows of good $k$ from region $i$ to region $j$

$$X_{ij,k} = \lambda_{ij,k}\beta_k E_j$$

- Trade Balance: $Y_j = E_j$

# A Model with Endogenous Skill Supply

## Equilibrium in Steady State

Endogenous variables $\{w_{i,h}, w_{i,l}, H_i, L_i, \{Y_{i,k}\}_k, Y_i\}_i$ can be solved from:

- Labor Market Clearing Conditions
- Goods Market Clearing Conditions
- Endogenous Labor Supply Equations

Note: $Y_{i,k}$ is the value output of sector $k$ in region $i$

back

$$\frac{X_{i\ ROW,k}}{X_{CH\ ROW,k}} = \alpha \frac{E_{i,k}}{E_k} + \varepsilon_{i,k}.$$

$\alpha = 1 \implies$ classical measurement error and attenuation bias

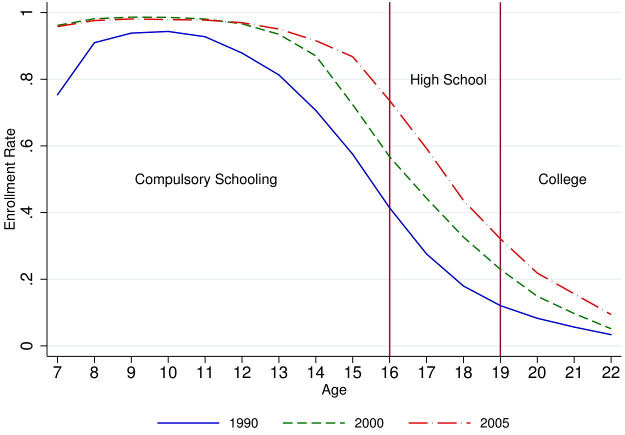
Table B.1: Shares of Export, Output and Employment

| | Export (1) | Export (2) | Output (3) | Export (4) | Export (5) | Output (6) |
|---|---|---|---|---|---|---|
| Employment | 1.104*** | | 0.899*** | 0.997*** | | 0.916*** |
| | (0.118) | | (0.183) | (0.124) | | (0.192) |
| Output | | 1.093*** | | | 1.100*** | |
| | | (0.107) | | | (0.112) | |
| Weighted | | | | Y | Y | Y |
| N | 9,860 | 9,860 | 9,860 | 9,860 | 9,860 | 9,860 |
| $R^2$ | 0.407 | 0.549 | 0.587 | 0.592 | 0.772 | 0.613 |

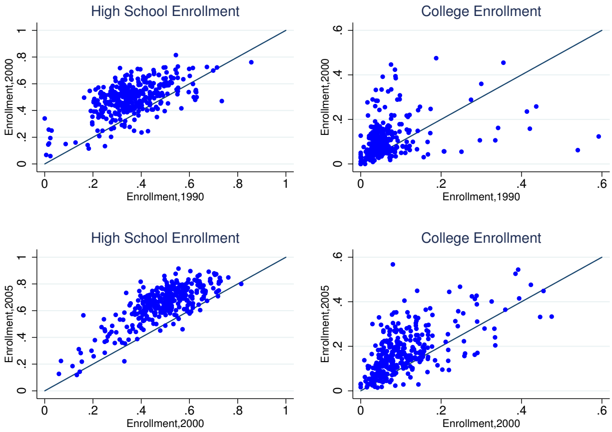
*** p<0.01, ** p<0.05, * p<0.1

back

Figure: School Enrollment by Age over Years



## Figure: School Enrollment across Prefectures of Different Periods

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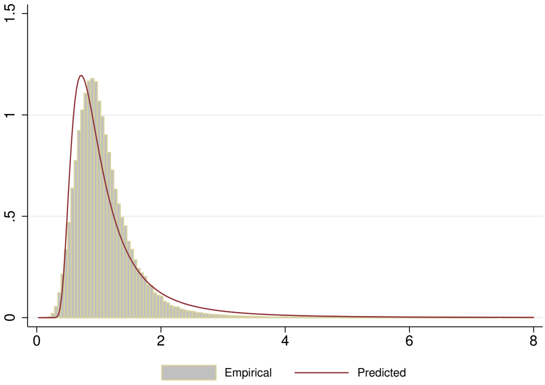
# Fréchet Distribution

$$F(z_h, z_l) = exp[-(z_h^{-\frac{\kappa}{1-\nu}} + z_l^{-\frac{\kappa}{1-\nu}})^{1-\nu}], \ \kappa > 1 \text{ and } 0 \leq \nu < 1$$

Figure: Empirical and Predicted Wage Distribution in 2005




▸ back

Table D.1: Educational Provision and Export Export Exposure

| | $\Delta \ln(FiscalExpEdu)$ | | $\Delta \ln(NbrMidSchTeacher)$ | |
|---|---|---|---|---|
| | (1) | (2) | (4) | (5) |
| $PLI$ | 0.216 | | 0.029 | |
| | (0.136) | | (0.156) | |
| $PHI$ | 2.603 | | -3.617 | |
| | (2.217) | | (3.559) | |
| $\Delta Export^{LS}$ | | 0.042* | | 0.021 |
| | | (0.021) | | (0.046) |
| $\Delta Export^{HS}$ | | -0.015 | | 0.005 |
| | | (0.009) | | (0.013) |
| Province(×Year) | Y | Y | Y | Y |
| $N$ | 680 | 680 | 340 | 340 |
| $R^2$ | 0.389 | 0.388 | 0.226 | 0.225 |

*Notes:* All regressions control for changes in log population of age groups 7-15, 16-18 and 19-22. Standard errors are clustered at the province level. *** p<0.01, ** p<0.05, * p<0.1

back

Table D.2: Changes in Share of Immigrants, Change in School Enrollment and Export Shocks: Different Samples by Migration Status

| | Age 16-18 | | | Age 19-22 | | |
|---|---|---|---|---|---|---|
| | $\Delta \frac{IM}{Pop}$ | $\Delta Enroll$ | $\Delta Enroll$ | $\Delta \frac{IM}{Pop}$ | $\Delta Enroll$ | $\Delta Enroll$ |
| | All | All | Non-migrants | All | All | Non-migrants |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\Delta Export^L$ | 0.017 | -0.029** | -0.019* | 0.007 | -0.027*** | -0.013* |
| | (0.011) | (0.012) | (0.011) | (0.009) | (0.006) | (0.008) |
| $\Delta Export^H$ | -0.001 | 0.004** | 0.006*** | 0.002 | 0.006*** | 0.004** |
| | (0.002) | (0.002) | (0.001) | (0.003) | (0.002) | (0.002) |
| Province | Y | Y | Y | Y | Y | Y |
| Controls | Y | Y | Y | Y | Y | Y |
| Initial Conditions | Y | Y | Y | Y | Y | Y |
| $PHI$ and $PLI$ | Y | Y | Y | Y | Y | Y |
| $N$ | 340 | 340 | 340 | 340 | 340 | 340 |
| $R^2$ | 0.594 | 0.694 | 0.633 | 0.718 | 0.662 | 0.703 |

*** p<0.01, ** p<0.05, * p<0.1

back

Table D.3: Changes in School Enrollment and Export Shocks: by Samples

| | Boy<br>(1) | Girl<br>(2) | Urban<br>(3) | Rural<br>(4) |
|---|---|---|---|---|
| **Panel A: Age 16-18** | | | | |
| $\Delta Export^L$ | -0.029*** | -0.041*** | -0.027* | -0.036*** |
| | (0.009) | (0.012) | (0.014) | (0.011) |
| $\Delta Export^H$ | 0.004 | 0.008*** | 0.008*** | 0.007*** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Province×Year | Y | Y | Y | Y |
| Controls | Y | Y | Y | Y |
| Initial Conditions | Y | Y | Y | Y |
| $PHI$ and $PLI$ | Y | Y | Y | Y |
| $N$ | 673 | 673 | 665 | 672 |
| $R^2$ | 0.640 | 0.716 | 0.729 | 0.707 |
| **Panel B: Age 19-22** | | | | |
| $\Delta Export^L$ | -0.029*** | -0.030*** | -0.028** | -0.015*** |
| | (0.006) | (0.005) | (0.011) | (0.004) |
| $\Delta Export^H$ | 0.009** | 0.005* | 0.018*** | 0.005*** |
| | (0.003) | (0.003) | (0.005) | (0.001) |
| Province×Year | Y | Y | Y | Y |
| Controls | Y | Y | Y | Y |
| Initial Conditions | Y | Y | Y | Y |
| $PHI$ and $PLI$ | Y | Y | Y | Y |
| $N$ | 673 | 673 | 673 | 673 |
| $R^2$ | 0.734 | 0.715 | 0.770 | 0.769 |

*** p<0.01, ** p<0.05, * p<0.1

▸ back

Table D.4: Dropping One Province/Two Provinces at a Time

| | Age 16-18 | | Age 19-22 | |
|---|---|---|---|---|
| | min($\hat{\beta}$) | max($\hat{\beta}$) | min($\hat{\beta}$) | max($\hat{\beta}$) |
| | (1) | (2) | (3) | (4) |
| **Panel A: Dropping one province at a time** | | | | |
| $\Delta Export^L$ | -0.050** | -0.026*** | -0.034** | -0.030*** |
| | (0.020) | ( 0.008) | (0.013) | (0.005) |
| $\Delta Export^H$ | 0.005** | 0.007*** | 0.006*** | 0.008*** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| **Panel B: Dropping two provinces at a time** | | | | |
| $\Delta Export^L$ | -0.060*** | -0.024*** | -0.040*** | -0.021* |
| | (0.019) | (0.007) | (0.013) | (0.012) |
| $\Delta Export^H$ | 0.004** | 0.009*** | 0.006** | 0.008*** |
| | (0.002) | (0.002) | (0.002) | (0.002) |

*** p<0.01, ** p<0.05, * p<0.1

back

Table D.7: Changes in School Enrollment, Export Shocks and Import Shocks: Disaggregated Education Groups

| | Age 16-18 | | | Age 19-22 | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\Delta Export^L$ | -0.019** | -0.025*** | -0.036 | -0.017*** | -0.027*** | -0.023* |
| | (0.007) | (0.009) | (0.023) | (0.004) | (0.005) | (0.012) |
| $\Delta Export^M$ | -0.005 | -0.007 | -0.022* | -0.004 | -0.004 | -0.019 |
| | (0.007) | (0.007) | (0.012) | (0.006) | (0.006) | (0.012) |
| $\Delta Export^H$ | 0.007*** | 0.006** | 0.011** | 0.011*** | 0.007*** | 0.012** |
| | (0.002) | (0.002) | (0.004) | (0.002) | (0.002) | (0.004) |
| Province×Year | Y | Y | Y | Y | Y | Y |
| Controls | Y | Y | Y | Y | Y | Y |
| Initial Conditions | Y | Y | Y | Y | Y | Y |
| $PHI$ and $PLI$ | | Y | | | Y | |
| Prefecture | | | Y | | | Y |
| N | 673 | 673 | 673 | 673 | 673 | 673 |
| $R^2$ | 0.682 | 0.693 | 0.925 | 0.696 | 0.762 | 0.920 |

*** p<0.01, ** p<0.05, * p<0.1

back

Table D.5: Change of School Enrollment and Export Shocks:
Ages under Compulsory Schooling

| | Age 7-12 | | | Age 13-15 | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\Delta Export^L$ | 0.001 | 0.001 | 0.001 | -0.005 | -0.006* | -0.012 |
| | (0.002) | (0.002) | (0.004) | (0.003) | (0.003) | (0.008) |
| $\Delta Export^H$ | -0.000 | -0.000 | -0.000 | 0.003*** | 0.002*** | 0.004* |
| | (0.000) | (0.000) | (0.001) | (0.001) | (0.001) | (0.002) |
| Province×Year | Y | Y | Y | Y | Y | Y |
| Controls | Y | Y | Y | Y | Y | Y |
| Initial Conditions | Y | Y | Y | Y | Y | Y |
| $PHI$ and $PLI$ | | Y | | | Y | |
| Prefecture | | | Y | | | Y |
| $N$ | 673 | 673 | 673 | 673 | 673 | 673 |
| $R^2$ | 0.956 | 0.956 | 0.995 | 0.858 | 0.859 | 0.980 |

*** p<0.01, ** p<0.05, * p<0.1

back

Table D.6: Changes of Market Employment, Home Production, Unemployment Rate and Export Shocks

| | Age 16-18 | | | Age 19-22 | | |
|---|---|---|---|---|---|---|
| | $\Delta Market$ $Empl.$ (1) | $\Delta Home$ $Prod.$ (2) | $\Delta Unemp.$ $Rate$ (3) | $\Delta Market$ $Empl.$ (4) | $\Delta Home$ $Prod.$ (5) | $\Delta Unemp.$ $Rate$ (6) |
| $\Delta Export^L$ | 0.036*** | 0.001 | -0.011* | 0.039*** | -0.001 | -0.012*** |
| | (0.009) | (0.002) | (0.006) | (0.004) | (0.001) | (0.003) |
| $\Delta Export^H$ | -0.006** | 0.000 | 0.002 | -0.009*** | 0.001 | 0.002 |
| | (0.002) | (0.000) | (0.003) | (0.002) | (0.000) | (0.001) |
| Province×Year | Y | Y | Y | Y | Y | Y |
| Controls | Y | Y | Y | Y | Y | Y |
| Initial Conditions | Y | Y | Y | Y | Y | Y |
| $PHI$ and $PLI$ | Y | Y | Y | Y | Y | Y |
| $N$ | 673 | 673 | 673 | 673 | 673 | 673 |
| $R^2$ | 0.713 | 0.279 | 0.545 | 0.781 | 0.300 | 0.635 |

*** p<0.01, ** p<0.05, * p<0.1

back

Table D.9: Change in School Enrollment, Export Shocks and Change in FDI

| | Age 16-18 | | | Age 19-22 | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\Delta Export^L$ | -0.029** | | -0.014* | -0.027*** | | -0.023*** |
| | (0.012) | | (0.008) | (0.006) | | (0.007) |
| $\Delta Export^H$ | 0.004** | | 0.004** | 0.006*** | | 0.005** |
| | (0.002) | | (0.002) | (0.002) | | (0.002) |
| $\Delta FDI^L$ | | -0.036*** | -0.032*** | | -0.022*** | -0.014*** |
| | | (0.008) | (0.006) | | (0.004) | (0.002) |
| $\Delta FDI^H$ | | 0.000 | 0.002 | | -0.001 | 0.005 |
| | | (0.005) | (0.005) | | (0.004) | (0.004) |
| Province×Year | Y | Y | Y | Y | Y | Y |
| Controls | Y | Y | Y | Y | Y | Y |
| Initial Conditions | Y | Y | Y | Y | Y | Y |
| $PHI$ and $PLI$ | Y | Y | Y | Y | Y | Y |
| $N$ | 340 | 340 | 340 | 340 | 340 | 340 |
| $R^2$ | 0.694 | 0.705 | 0.709 | 0.662 | 0.656 | 0.671 |

*** p<0.01, ** p<0.05, * p<0.1

back

Table D.8: Changes in Skill Supply and Change in Industry Specialization: Different Measures

| | $\Delta Share^{Manuf.}$ | | | | $\Delta Share$ | |
|---|---|---|---|---|---|---|
| | Employment | | Output | | Employment | |
| | OLS | 2SLS | OLS | 2SLS | OLS | 2SLS |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $L \times \Delta HighSch.Share_{t-1}$ | -0.005 | 0.253** | -0.005 | 0.322* | -0.002 | 0.134** |
| | (0.021) | (0.099) | (0.033) | (0.187) | (0.005) | (0.061) |
| $M \times \Delta HighSch.Share_{t-1}$ | 0.013 | -0.040 | 0.005 | -0.196 | 0.002 | 0.024 |
| | (0.022) | (0.061) | (0.031) | (0.214) | (0.003) | (0.016) |
| $H \times \Delta HighSch.Share_{t-1}$ | -0.009 | -0.214** | 0.000 | -0.111 | 0.000 | -0.060* |
| | (0.016) | (0.089) | (0.032) | (0.212) | (0.004) | (0.033) |
| $L \times \Delta College.Share_{t-1}$ | -0.058 | -0.379*** | -0.055 | -0.388** | -0.017 | -0.245*** |
| | (0.037) | (0.140) | (0.049) | (0.156) | (0.013) | (0.087) |
| $M \times \Delta College.Share_{t-1}$ | -0.006 | 0.042 | 0.010 | 0.075 | -0.010 | -0.074*** |
| | (0.033) | (0.079) | (0.045) | (0.191) | (0.006) | (0.028) |
| $H \times \Delta College.Share_{t-1}$ | 0.064** | 0.337*** | 0.055 | 0.313* | 0.003 | 0.087* |
| | (0.028) | (0.125) | (0.050) | (0.175) | (0.007) | (0.051) |
| $\Delta ShareEmp^{Manuf.}_{t-1}$ | Y | Y | Y | Y | | |
| $\Delta ShareEmp_{t-1}$ | | | | | Y | Y |
| Province×Ind | Y | Y | Y | Y | Y | Y |
| N | 8,721 | 8,721 | 9,180 | 9,180 | 8,721 | 8,721 |

*** p<0.01, ** p<0.05, * p<0.1

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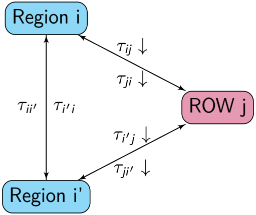
# Counterfactual Analysis

- The model can provide quantitative answers to the questions:
  - How the trade liberalization in the past decades affect welfare and educational attainment across regions?
  - Implications of further trade liberalization on China's regional divergence/inequality




- "Exact Hat Algebra": Only consider the changes from the current equilibrium $\implies$ No need to calibrate all the parameters. (Dekle et al., 2008; Costinot and Rodríguez-Clare, 2014)

# Counterfactural Analysis

- $\hat{x} \equiv x'/x$ denotes the proportional change in any variable $x$ between the counterfactual and initial equilibria.
- "Exact Hat Algebra": Only consider the changes from the current equilibrium $\implies$ No need to calibrate all the parameters. (Dekle et al., 2008; Costinot and Rodríguez-Clare, 2014)
- Mapping from $\{\hat{\tau}_{ij,k}\}$ to $\{\hat{w}_{i,h}, \hat{w}_{i,l}, \hat{Y}_i, \hat{Y}_{i,k}, \hat{\lambda}_{ij,k}, \hat{H}_i, \hat{L}_i\}$, given:
  - Parameters $\{\alpha_k, \beta_k, \varepsilon, \kappa, \nu\}$
  - Initial values $\{Y_{i,k}, Y_i, \lambda_{ij,k}, h_{i,k}, l_{i,k}, \pi_{i,h}\}$
- Proportional Changes in Welfare, $\hat{C}_i = \hat{Y}_i/\hat{P}_i$

# Counterfactural Analysis
## Calibration

- 9 Regions (8 China's regions and ROW) and 14 sectors
- Calibrate all variables and parameters, except $\nu$ (corr. $z_h$ & $z_l$)
- Baseline $\nu = 0.1$ (Hsieh, et al., 2013)

| Variables and Parameters | Data |
|---|---|
| Income($Y_i$), bilateral tradeflows($\lambda_{ij,k}$)<br>sectoral output($Y_{i,k}$), & consumption share($\beta_k$) | China Regional IO Table, 2007<br>& WIOT, 2007 |
| Employment share of skilled<br>and unskilled labor($h_{i,k}$ and $l_{i,k}$) | China 2005 Mini Census<br>& WIOT SEA, 2007 |
| Income share of skilled workers($\alpha_k$) | China 2005 Mini Census |
| School enrollment rate($\pi_{i,h}$) | China 2005 Mini Census<br>Barro and Lee, 2005 |
| Trade elasticity ($\varepsilon = 4.14$) | Simonovska and Waugh (2014) |
| Skill distribution parameter ($\kappa = 3.41$) | China 2005 Mini Census |

# Counterfactual Analysis

## Shutting down External Trade

$$\hat{\tau}_{ij,k} = \begin{cases} +\infty & \text{if } i \neq \text{ROW} \ \& \ j = \text{ROW}; \\ +\infty & \text{if } i = \text{ROW} \ \& \ j \neq \text{ROW}; \\ 1 & \text{otherwise.} \end{cases}$$

Table: Counterfactual – Eliminating External Trade

| Region | (1) $\pi_{ih}$ | (2) $\frac{\hat{w}_{i,h}}{\hat{w}_{i,l}}$ | (3) $\hat{\pi}_{ih}$ | (4) $\%G$ |
|---|---|---|---|---|
| Northeast | 0.167 | 1.008 | 1.027 | 2.778 |
| North Municipalities | 0.452 | 0.993 | 0.986 | 6.353 |
| North Coast | 0.118 | 1.013 | 1.044 | 1.805 |
| Central Coast | 0.290 | 1.022 | 1.060 | 6.713 |
| South Coast | 0.136 | 1.007 | 1.024 | 7.300 |
| Central | 0.116 | 1.006 | 1.019 | 1.602 |
| Southwest | 0.088 | 1.005 | 1.016 | 2.792 |
| Northwest | 0.117 | 1.006 | 1.022 | 1.722 |

*Notes:* Gains from trade $\%G = (1 - \hat{C}) \times 100$.

# Counterfactural Analysis

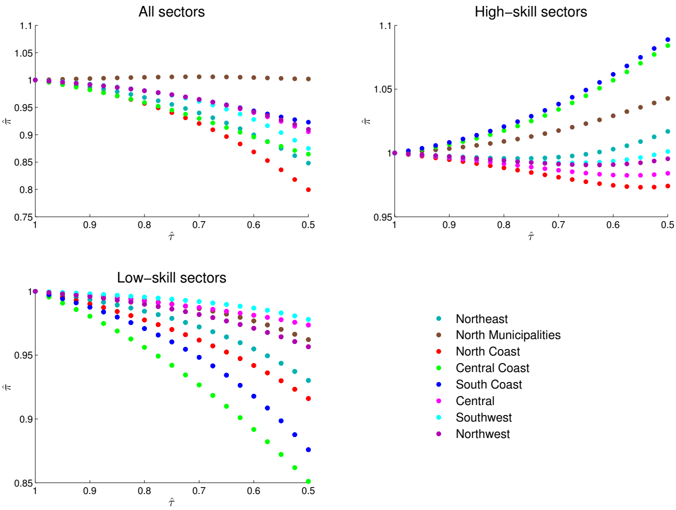
## Further Trade Liberalization

$$\hat{\tau}_{ij,k} = \begin{cases} 0.7 & \text{if } i \neq \text{ROW} \ \& \ j = \text{ROW}; \\ 0.7 & \text{if } i = \text{ROW} \ \& \ j \neq \text{ROW}; \\ 1 & \text{otherwise.} \end{cases}$$

Table: Counterfactual – Further Trade Liberalization

| | All Ind. | | | High skill ind. | | | Low skill ind. | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\frac{\hat{w}_{i,h}}{\hat{w}_{i,l}}$ | $\hat{\pi}_{ih}$ | $\%C$ | $\frac{\hat{w}_{i,h}}{\hat{w}_{i,l}}$ | $\hat{\pi}_{ih}$ | $\%C$ | $\frac{\hat{w}_{i,h}}{\hat{w}_{i,l}}$ | $\hat{\pi}_{ih}$ | $\%C$ |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Northeast | 0.981 | 0.940 | 8.347 | 0.999 | 0.997 | 4.275 | 0.991 | 0.972 | 1.724 |
| North Mun. | 1.003 | 1.006 | 16.109 | 1.008 | 1.018 | 8.255 | 0.993 | 0.986 | 2.471 |
| North Coast | 0.976 | 0.920 | 5.562 | 0.994 | 0.981 | 2.148 | 0.988 | 0.962 | 1.285 |
| Central Coast | 0.974 | 0.930 | 15.212 | 1.013 | 1.034 | 6.996 | 0.972 | 0.927 | 3.382 |
| South Coast | 0.989 | 0.965 | 15.933 | 1.012 | 1.038 | 9.614 | 0.984 | 0.948 | 1.774 |
| Central | 0.989 | 0.964 | 5.003 | 0.996 | 0.986 | 3.283 | 0.996 | 0.987 | 0.765 |
| Southwest | 0.989 | 0.961 | 8.206 | 0.998 | 0.992 | 4.559 | 0.998 | 0.992 | 1.467 |
| Northwest | 0.989 | 0.964 | 5.541 | 0.997 | 0.991 | 3.521 | 0.995 | 0.982 | 1.009 |

# Figure: Divergence in Educational Attainment



# Regions in Counterfactual Analysis

Figure: Regions in Counterfactual Analysis